Woodward-Clyde Consultants

DOUGLAS AIRCRAFT COMPANY
TORRANCE (C6) FACILITY
PHASE III GROUND WATER AND SOIL
INVESTIGATION WORK PLAN
9 February 1989

Prepared for:

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Project No. 8841863G

(d-bj/dacc6p3)

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DOUGLAS AIRCRAFT COMPANY

TORRANCE (C6) FACILITY

PHASE III GROUND WATER AND SOIL

INVESTIGATION WORK PLAN

1.0 INTRODUCTION

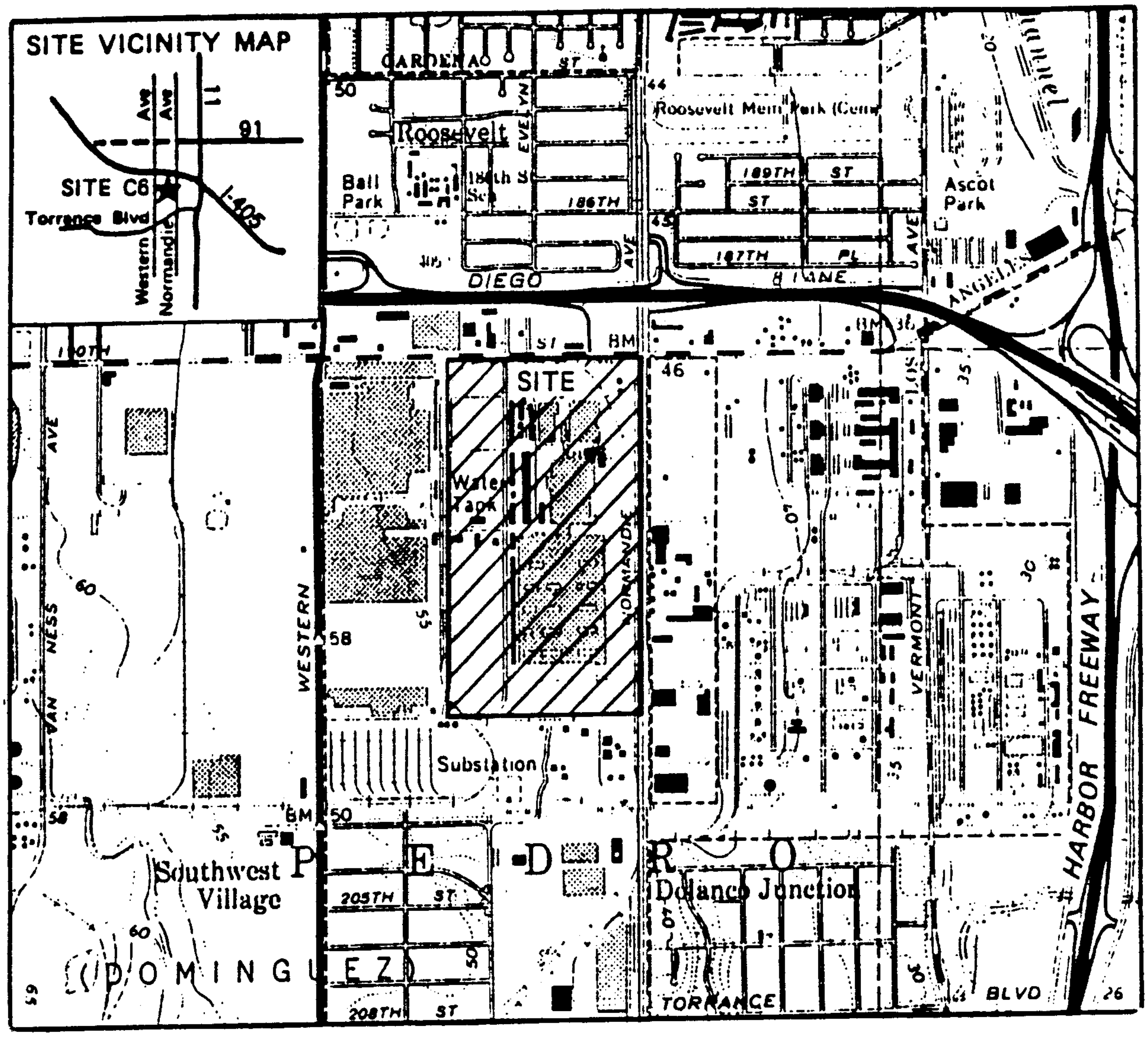
Woodward-Clyde Consultants (WCC) is pleased to present this work plan directed toward the following objectives:

- To evaluate the vertical and lateral extent of volatile organic compounds (VOCs) in the soil and ground water at the C6 (Torrance) Facility of Douglas Aircraft Company (DAC)
- To develop data and information on site soil and ground water conditions that would allow design of a remediation program.

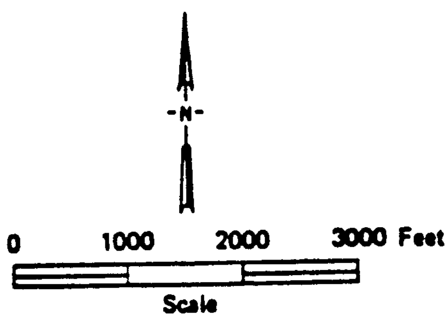
The C6 Facility is located at 19503 South Normandie in Los Angeles, California (see Figure 1). The facility is often referred to as the Torrance Facility because of its proximity to the city of Torrance. The suspected source of the VOCs at the facility is Tank Cluster 15T through 18T, located to the south of Building 36 (see Figure 2).

1.1 Previous Investigations

WCC has conducted two previous investigations in this area. The first investigation was directed toward evaluation of the vertical extent of fuel oil in the soil under Building 41 resulting from a pipeline leak associated with Tanks 19T and 20T. The results from this investigation, presented in a report entitled "Leak Investigation at Douglas Aircraft Company's C6 Facility, Los Angeles, California," dated April 1987, indicated the presence of fuel oil to a depth of at least 50 feet below the surface inside Building 41, near the suspected source of the leak.



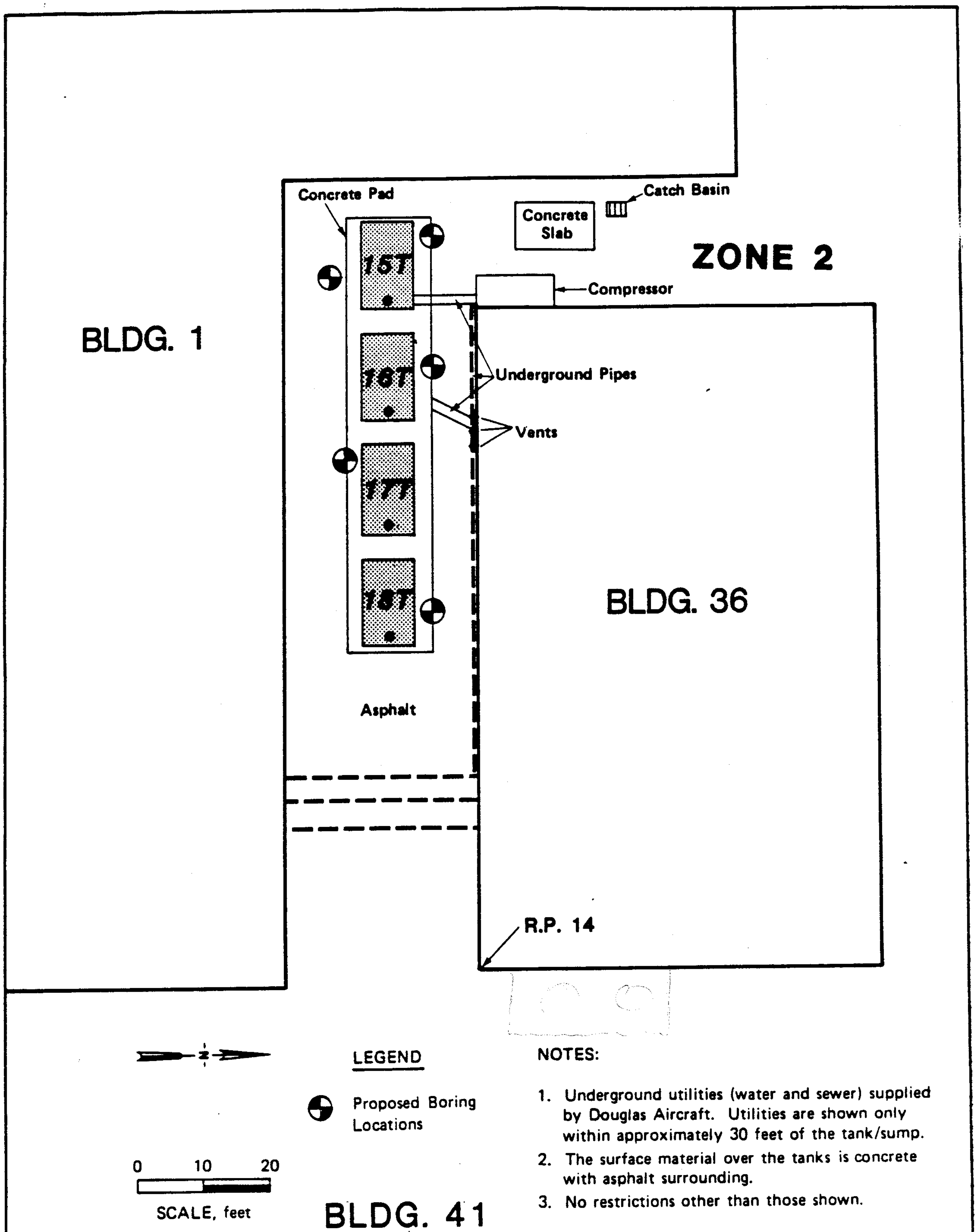
C6 FACILITY



Project: DOUGLAS AIRCRAFT CO. **Project No.** 41863D	C6 FACILITY LOCATION MAP

Fig. 1

WOODWARD-CLYDE CONSULTANTS



LEGEND

Proposed Boring Locations

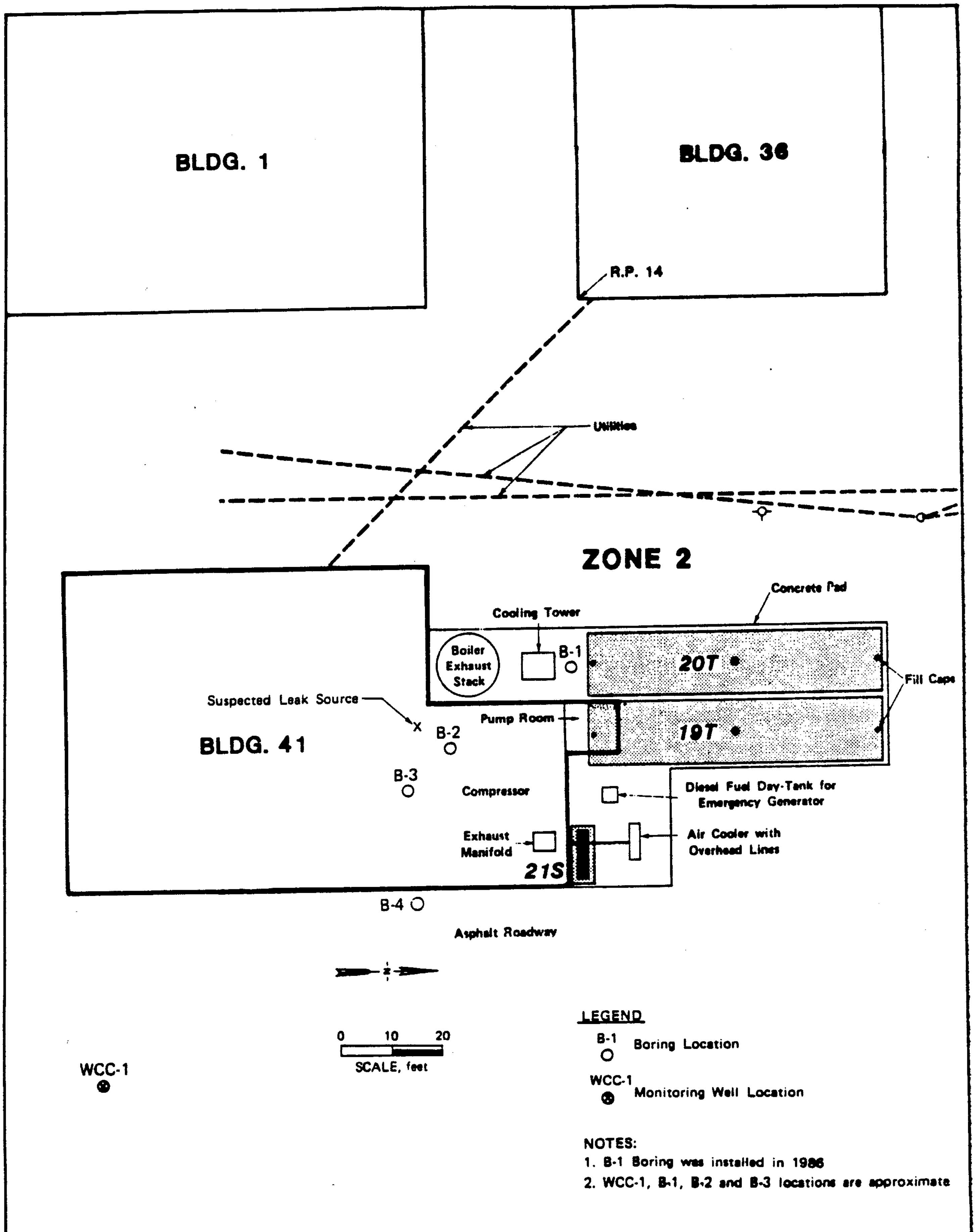
NOTES:

1. Underground utilities (water and sewer) supplied by Douglas Aircraft. Utilities are shown only within approximately 30 feet of the tank/sump.
2. The surface material over the tanks is concrete with asphalt surrounding.
3. No restrictions other than those shown.

August 1988

Project: DOUGLAS AIRCRAFT CO. Project No. 8741863C-PHASE III	PROPOSED BORING LOCATIONS FOR THE PHASE III SOIL AND GROUNDWATER INVESTIGATION	Fig. 2

WOODWARD–CLYDE CONSULTANTS



November 1987

Project DOUGLAS AIRCRAFT CO. Project No. 41863B	LOCATION MAP FOR WCC-1, B-1, B-2, B-3 and B-4.	Fig. 3

Borings advanced outside this building did not encounter fuel oil in the soil, indicating that the lateral extent of fuel oil was apparently confined to the soil column underlying the building. Boring locations for the Phase I investigation are presented on Figure 3.

Ground water samples from a monitoring well (WCC-1) installed downgradient of Tanks 19T and 20T indicated the presence of the halogenated solvents trichloroethylene (TCE), 1,1,1,-trichloroethane (1,1,1-TCA), and 1,1-dichloroethylene (1,1-DCE), as well as benzene. These substances were different from those expected to be present if fuel oil was the source of the compounds in the affected ground water.

The second investigation evaluated the source of organic compounds in the soil and ground water near Tanks 19T and 20T. Results of the investigation are presented in "The Final Report on Phase II of the Subsurface Investigation at Tanks 19T and 20T at the C6 Facility," dated 10 May 1988. This investigation involved installation of four additional observation wells of approximate 90-foot depth and one angle boring, B-4. Boring B-4 was located to the east of Building 41, as shown in Figure 3. The observation well locations are illustrated in Figure 4. ← NO FIG 4!

The primary results from the Phase II investigation were as follows:

- The direction of the ground water gradient is from northwest to southeast (refer to Figure 4). NO FIG 4!
- Analytical results obtained from water samples collected from Wells WCC-1, -2, -3, -4, and -5 showed the presence of halogenated hydrocarbons, as well as benzene and toluene, in all the water samples. The distribution of organic compound concentrations

appeared to indicate a possible source of these compounds near Tank Cluster 15T through 18T (see Table 1).

- Data obtained from the observation wells and Boring B-4 indicated that the piping at Tanks 19T and 20T was probably not the source of the organic compounds identified in the ground water; the area near Tank Cluster 15T through 18T, however, appeared to be a possible source. In addition, the petroleum hydrocarbons did not appear to have penetrated more than 50 feet below the surface, and were probably confined to a part of the area under Building 41.

- Water samples from Well WCC-2, the well upgradient of the suspected source of the release, and from Well WCC-5, the downgradient well, had similar low concentrations of volatile organic compounds, possibly indicating that ground water entering the site contains low levels of these organic compounds.

1.2 Regional Hydrogeologic Setting

The C6 Facility is sited in the Torrance Plain. The following discussion of the regional hydrogeologic setting for the Torrance Plain is based primarily on the United States Geological Survey (U.S.G.S.) Water Supply Paper 1461 (Poland, 1959), the Department of Water Resources (DWR) Bulletin 104, and data from the Los Angeles County Flood Control District (LACFCD).

The major water-bearing aquifers beneath the Torrance Plain in the vicinity of the site, from deep to shallow, include the Silverado (at depths as great as 700 feet), the "400-foot gravel" (also known as the Lynwood Aquifer and referred to herein as such), and the late Pleistocene "200-foot sand" (also known as the Gage Aquifer and referred to herein as such). The Silverado and Lynwood aquifers collectively form the water-bearing zones of the early Pleistocene San Pedro Formation. The upper Pleistocene Lakewood Formation consists of the semi-perched zone, the

TABLE 1

GROUND WATER ANALYTICAL DATA

Concentrations (ug/l)

COMPOUNDS	WCC-1			WCC-2		WCC-3		WCC-4		WCC-5	
	3/27/87	4/13/87*	11/12/87	11/2/87	11/12/87	11/2/87	11/12/87	11/2/87	11/12/87	11/30/87	1/8/88
1,1-Dichloroethene (1,1-DCE)	2,800	3,700/2,500	3,000	5	2	38,000	88,000	360	1,200	7	4
1,1-Dichloroethane (1,1-DCA)	--	--/--	23	--	--	--	1,000	--	--	--	--
1,1,1-Trichloroethane (1,1,1-TCA)	300	260/120	160	5	--	110,000	54,000	14	35	--	--
Trichloroethene (TCE)	4,600	5,500/3,600	5,200	14	4	10,000	11,000	700	690	1	10
4-Methyl-2-pentanone (MIBK)	--	--/--	--	--	--	54,000	70,000	--	--	--	--
trans-1,2-dichloroethene (trans-1,2-DCE)	--	--/--	75	--	--	--	1,000	2	--	--	--
Chloroform	--	--/--	39	--	--	--	--	2	--	--	--
Toluene	--	--/--	--	6	1	80,000	140,000	--	--	1	--
Benzene	85	110/--	160	--	--	--	--	--	--	--	--
Detection level (ug/l)	50	50/50	20	1	1	1,000	1,000	1	10	1	1

* Duplicate sample also analyzed
-- Not detected

(L-ABC/D-Table 2)

BOE-C6-020658

Bellflower Aquiclude, and the Gage Aquifer. These are all considered to be shallow aquifers, while the lower Pleistocene aquifers are normally termed deep aquifers.

Areal extent of the aquifers varies over the region. The Silverado and Gage aquifers are continuous from Hawthorne to Palos Verdes. The Lynwood Aquifer, however, thins out considerably in the site vicinity and disappears a few miles to the south.

The site vicinity lacks deposits of recent age that occur over much of the Torrance Plain. Aquifers such as the Gaspur Aquifer (also known as the "50-foot gravel") and alluvium deposits are found in the Santa Monica and Long Beach area, but have not been identified in the vicinity of Torrance.

According to the information obtained from the Los Angeles Flood Control District, the shallow aquifers, including the Gage, are not used for domestic or industrial purposes. Mitchell (1982) of the Water Quality Division of LACFCD has stated that the shallow aquifers are polluted with brines and industrial wastes, rendering them unsuitable for domestic purposes.

The deep aquifers are extensively tapped by wells for various uses and are collectively regarded as the principal water body. Within much of the Torrance Plain, the aquifers of the principal water body are separated by substantial thicknesses of low permeability silt or clay. These beds of silt or clay effectively confine the water in the aquifer and prevent free circulation from one aquifer to another.

For example, nearly 100 feet of silt and clay separate the Gage Aquifer from the Lynwood Aquifer and the Silverado Aquifer from the Lynwood Aquifer in the site vicinity.

Information concerning ground water conditions in the semi-perched aquifers in the area (shallower than the Gage Aquifer) is not available from published literature, nor are these data collected by local water agencies. Data on semi-perched ground water conditions in the area are normally available only from environmental investigations performed by private consulting companies. Pertinent site-specific ground water investigations are discussed in Section 1.3.

Although site-specific data are not available, a generalized statement about the Gage Aquifer at the site may be inferred from drilling logs and water well information obtained for other wells in the region. In the site vicinity, the Gage Aquifer apparently forms a layer of sands and gravels about 50 to 100 feet thick, the top of which occurs approximately 150 feet below ground surface.

Natural recharge of the deep aquifers occurs north of the site in the mountains and alluvial fans bordering the Los Angeles Basin. The shallow and semi-perched aquifers are recharged by direct percolation from the ground surface throughout the basin and by underflow from the recharge areas at the heads of the alluvial fans.

Recharge by precipitation in the Los Angeles Basin occurs primarily during December through April (Dedrick et al., 1977). Mean annual rainfall in the site vicinity is 12 to 14 inches per year (Dedrick et al., 1976, 1977). Natural recharge to all aquifers has been reduced by urbanization and industrialization in the northern recharge area. Channelizing the Los Angeles and San Gabriel rivers also has reduced recharge to the deep aquifers from these sources. To compensate for the lost natural recharge areas and the heavy use of ground water, artificial recharge programs have been developed.

1.3 Site Hydrogeologic Setting

The present understanding of the site hydrogeology is based primarily on data from environmental investigations conducted by WCC at the C6 Facility (1987) and the Del Amo Hazardous Waste Site (1987), and by Hargis and Associates at the Montrose Facility (1986). These investigations involved evaluations of the soil and ground water conditions beneath the sites; they provide lithologic information on the strata overlying the Gage Aquifer.

The major water-bearing zones of interest beneath the site are the Gage Aquifer and the shallower semi-perched aquifer. Data from the investigation at the Del Amo Hazardous Waste Site, located southeast of the C6 Facility, indicate that the top of the Gage Aquifer is approximately 150 to 160 feet below ground surface. Although not estimated in the investigation, the total thickness of the Gage Aquifer may range from 50 to 100 feet, based on data from adjacent sites.

The semi-perched aquifer is apparently located approximately 70 feet below ground surface at the site and extends to the top of the Gage Aquifer, a depth of approximately 80 feet. Overlying the aquifer are upper Pleistocene deposits of the Lakewood Formation consisting predominantly of silts, clays, and sand zones.

2.0 OBJECTIVE

The objective of this work plan is to present a method of evaluating the lateral and vertical distribution of organic compounds in the soil and ground water near Tank Cluster 15T through 18T. Additionally, WCC will develop the data and information needed to design a soil and ground water remediation program. The specific objectives of this work plan are:

1) To evaluate the quality of ground water entering the site.

2) To assess the lateral and vertical configuration of the onsite organic compounds in the ground water within the semi-perched aquifer.

3) To evaluate the potential for offsite migration of the organics in the ground water.

4) To obtain quantitative estimates for aquifer parameters in the shallow and deep zones within the semi-perched aquifer (down to 130 to 150 feet). These parameters will be required for design of a remedial program.

5) To estimate the lateral and vertical extent of organics in the soil around Tank Cluster 15T through 18T.

These objectives will be accomplished using the approach described in Section 3.0.

3.0 PROPOSED INVESTIGATIVE PROGRAM

WCC proposes the following program consisting of four tasks.

3.1 Task I - Installation of Observation Wells and Soil Borings Adjacent to Tank Cluster 15T - 18T

Task I involves installation of five shallow (approximately 95 feet) and three deep (approximately 130 to 150 feet) 4-inch diameter observation wells. Plate 1 shows the proposed locations. These observation wells will be developed, sampled, and analyzed for VOCs by EPA Method 624 (8240). Well construction and field procedures are discussed in Appendix A.

This task involves partitioning the semi-perched aquifer into an upper and a lower zone. The upper zone wells will be screened from 60 to 95 feet, where static water level is approximately 70 feet below ground surface. The lower zone wells will be screened from approximately 120 to 140 feet. Installation of observation wells within both the upper and lower zones of the semi-perched aquifer is necessary to evaluate differences in vertical hydraulic gradient and concentrations of organic compounds within the semi-perched aquifer.

The Task I well installation program will be implemented as follows:

- o Wells WCC-1D, -3D, -7S, -8S, and -10S will be installed first. Well WCC-10S will be used to evaluate the quality of the ground water entering the C6 Facility from the west. Wells WCC-1D and -3D will provide information on the water quality in the lower portion (130- to 150-foot depth) of the semi-perched aquifer. The location of Wells WCC-7S and -8S will be selected using estimates of the probable lateral spreading of the organic compounds in the ground water based on the observed variation in the direction of the gradient. Wells WCC-7S and -8S will be located, if possible, so that they are at the edges of the zone of ground water with elevated concentrations of organic compounds.

- o Wells WCC-6S, -9S, and -6D will be installed if the results obtained from the earlier well installation indicate that they are needed. Their purpose would be to identify whether organics were present in the ground water at their proposed location. This information could be needed to help delineate the extent of organics in the ground water.

Four or five soil borings approximately 60 feet deep will also be advanced during Task I, to assess the vertical and lateral extent of organic compounds in the soil at Tank Cluster 15T through 18T (see Figure 2 for proposed boring locations). These soil borings will provide information needed to construct geologic cross sections to assist in evaluating the volume of soil with elevated concentrations of organic compounds. Approximately three cross sections will be constructed. This information will be needed for the development of a soil remediation program. Soil samples collected from these borings will be analyzed for VOCs by EPA Method 8240. Soil sampling and field procedures are discussed in Appendix A.

3.1.1 Task IA - Aquifer Slug Testing

Task IA involves conducting slug tests on six shallow and up to three deep observation wells. The slug tests will provide a relatively inexpensive and rapid method of obtaining preliminary estimates of horizontal hydraulic conductivity in the shallow and deep zones within the upper aquifer. These data will assist in evaluating the horizontal and vertical ground water velocity and the potential areal configuration of the organics in the ground water.

3.2 Task II - Installation of Additional Observation Wells

Task II may include installation of an additional three or four shallow and two or three deep observation wells for further delineation of organics in the ground water, if necessary. These wells will also provide additional information for remediation design parameters, such as number of recovery wells, volume of ground water, and treatment time. The exact number and locations of additional observation wells, if any, will depend on analytical data, aquifer characteristics, and lithologic data collected during Tasks I and IA.

If organic compounds appear to be present in the deep observation wells installed in Tasks I and II, installation of an observation well(s) in the Gage Aquifer (depth of 180 to 200 feet) may be necessary to evaluate whether organic compounds have migrated through the clay layers overlying the Gage Aquifer.

All observation wells installed under Task II will be constructed, developed, and sampled as described in Appendix A.

3.2.1 Task IIA - Aquifer Slug Testing of Task II Observation Wells

Task IIA involves aquifer slug tests for the additional observation wells installed during Task II. A maximum of six slug tests between the shallow and deep wells will be conducted. These tests will provide additional information for estimating deep and shallow aquifer characteristics and refinement of the vertical and lateral extent of organic compounds in the ground water.

3.3 Task III - Recovery Well and Aquifer Testing

Task III will involve installing one 6-inch pumping/recovery well (RW-1) and conducting one 48-hour aquifer pumping test on RW-1. This test will be conducted to evaluate aquifer characteristics under pumping "stress" in the shallow and deep zones of the semi-perched aquifer. Aquifer pumping tests can provide more representative aquifer data than slug tests, because they generate a larger radius of influence than slug tests. Data from this test, combined with data from slug tests (Tasks IA and IIA), will provide aquifer parameter information such as transmissivity, storativity, radius of influence, and specific capacity, which will be required for development of a ground water remediation program. The data will also allow better assessment of ground water velocity and potential migration distance of organic compounds.

The approximate location of RW-1 is illustrated on Plate 2. The total depth and screened interval of this well will depend on ground water analytical results from Wells WCC-3S and -3D. If organic compounds are found in the shallow zone (Well WCC-3S), but not in the deep zone (Well WCC-3D), RW-1 will be screened only in the upper zone to minimize the potential for organic compounds migrating into the lower section of the aquifer. However, if analytical results from Wells WCC-3S and -3D indicate organic compounds in the shallow and deep aquifer zones, RW-1 will be screened through the upper and lower zones.

Task III will also include selection and installation of a pilot ground water treatment system designed to treat the ground water produced by the aquifer pump test, which could total an estimated 150,000 gallons. Depending on the results from task activities described above, the treatment system may consist of either a portable, trailer-mounted, mobile facility or actual installation of a pilot treatment facility for ground water produced from the aquifer pump tests.

3.4 <u>Task IV - Final Report Preparation</u>

Task IV will involve the compilation, analysis, and evaluation of the data generated under this work program.

The results of this evaluation will be integrated with data from previous investigations and used to prepare a summary report. This report will include the following elements:

- A discussion of the geologic and hydrogeologic framework controlling migration of organics at the site
- A description of drilling, sampling, and analytical procedures utilized in the completion of task activities
- A discussion of the results obtained from the soil and ground water sampling program
- Estimates of the lateral and vertical extent of organic compounds in the ground water and soil around Tank Cluster 15T through 18T.

4.0 SCHEDULE

WCC proposes completing this investigation within approximately eight months from receiving authorization from DAC to proceed and following approval of the work plan by the Los Angeles Regional Water Quality Control Board. The proposed schedule is presented in Plate 2, and a critical path flow chart is provided in Plate 3.

5.0 REFERENCES

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APPENDIX A

FIELD PROCEDURES AND METHODOLOGY

(d-bj/dacappa)

APPENDIX A

FIELD PROCEDURES AND METHODOLOGY

A.1 GENERAL INFORMATION

A.1.1 Observation Well Installation - Shallow

Shallow observation wells will be constructed of 4-inch O.D., Schedule 40, PVC casing and screen and set to a depth of about 95 feet. The shallow observation wells will be installed by drilling a 95-foot deep hole with a nominal 10-inch O.D. hollow-stem auger. A wooden plug will be placed in the lead cutting auger to prevent cuttings and water from entering the inside of the auger. Municipal water may be added to the inside of the auger as drilling progresses through the water table to offset hydrostatic pressure of any fine-grained flowing sands outside the auger. During the Phase II investigation (18 April 1988), two attempts were made to install Well WCC-3 without the use of water; however, the bottom 3 to 5 feet of the auger "sanded-in" immediately after knocking out the wooden plug. The "sanding-in" of the auger prevented the wells from being properly constructed. Subsequently, water had to be used for proper construction of Wells WCC-2, -3, -4, and -5. The volumes of municipal water used in the construction of each well will be noted on the well log forms, and samples of municipal water will be collected for possible laboratory analysis.

A.1.2 Well Construction - Shallow

The shallow observation wells will be constructed of 4-inch O.D., Schedule 40, PVC flush-threaded blank pipe. We anticipate that the wells will be screened with 0.010-inch slot screen, but actual slot size will be dependent on soil sieve analysis. Adhesives will not be used. Wells will be installed with 65 feet of blank casing and 30 feet of screen.

The well screen will be filter-packed using a tremie pipe to reduce the possibility of sand bridging inside the auger. A filter pack material will be selected based on a field sieve analysis; filter pack analysis is discussed in Section A.4. The filter pack will be placed from the well bottom to about 5 feet above the top of the well screen (depth range from approximately 60 feet to 95 feet).

A 5-foot thick bentonite pellet plug will be placed above the filter pack, at depths from about 50 ~~55~~ to 55 ~~60~~ feet, to minimize movement of fluids through the annular space. In addition, bentonite grout will be placed at a depth range of approximately 8 to 55 feet below ground surface. To minimize seepage of surface fluids into the well, a concrete plug will be placed from approximately 8 feet to the surface. The top of the well casing will be completed 3 to 6 inches below grade and protected with a steel traffic-rated Christy box. Figure A-1 illustrates the basic well construction design for a shallow observation well.

A.1.3 <u>Observation Well Installation - Deep</u>

Deep observation wells will be constructed of 4-inch O.D., Schedule 80, PVC casing and set to a depth of between 130 and 150 feet. The deep observation wells will be installed using a reverse-circulation mud rotary method. This drilling method employs a bentonite drilling fluid to seal off the upper zone, allowing the well to be set and grouted to prevent cross-contamination from the upper zone of the aquifer. Once the total depth of the hole is attained, the drilling rod will be removed from the borehole to set the well casing and screen. The rotary method also was selected to prevent flowing sands from collapsing the borehole and to enable proper construction of the observation well. Samples of drilling fluid and water used in construction of these wells may be analyzed for organics (EPA Method 8240) to minimize possible cross contamination.

A.1.4 Well Construction - Deep

The deep observation wells will be constructed of 4-inch O.D., Schedule 80, PVC flush-threaded blank pipe. It is anticipated that the wells will be screened with 0.010-inch slot screen, but actual slot size will be dependent on soil sieve analysis. Adhesives will not be used. Wells will be installed with 110 to 130 feet of blank casing (depending on final total depth) and 20 feet of screen. The following procedure will be used for the installation of deep observation wells in the boreholes drilled by mud rotary techniques.

After measuring the depth of the completed boring, a 1-foot thick layer of sand/gravel filter pack will be placed in the bottom of the boring using a 2-inch diameter tremie pipe. The completed well will be supported by a grab-vise at the top of the borehole so that the bottom of the screen is slightly above the bottom of the hole and the entire assembly is under tension. The filter pack will then be installed in the annular space using a 2-inch diameter tremie pipe to minimize the potential for particle grading or bridging. The filter pack material will be fed into a hopper at the well head, and 5 to 10 gallons of water for each cubic foot of filter pack material will be introduced with the filter pack to prevent bridging in the pipe and thin the drilling fluid. The tremie pipe will be raised periodically as the filter material accumulates around the screen. Repeated depth soundings of the bottom of the hole will be taken to monitor the level of the filter pack and detect any bridging. The filter pack will extend above the top of the ~~well~~ screen for a distance of about ~~2~~ 5 feet. The final depth to the top of the filter pack will be recorded.

A 4-foot thick bentonite seal will be emplaced above the filter pack as a slurry using a tremie pipe. The remaining annular space will be grouted to approximately 8 feet below ground surface with a cement/bentonite mixture or volclay-type bentonite grout; the grout will be placed using a tremie pipe. The remaining annular space will be filled to the surface with concrete. Before the concrete sets, a protective steel traffic-rated well cover will be centered over the well head and set into the concrete. Figure A-2 illustrates the basic well design for a deep observation well.

A.1.5 <u>Recovery/Pumping Well Installation (RW-1)</u>

Installation of Well RW-1 will employ the drilling method described in Section A.1.3. The well will be constructed using 6-inch stainless steel screen and Schedule 80 PVC blank casing. The exact lengths of screen and blank casing will be decided based on results from Task I. Well screen size and filter pack material will be selected based on soil sieve analysis as described in Section A.4.

A.1.6 <u>Drilling Residuals</u>

Drill cuttings from each boring will be placed in DOT Class 17H 55-gallon drums. The contents of the drums will be labeled using an identification label and permanent ink marker. Information on the label will include well or boring number, date, owner, facility contact name, and telephone number. The drums will be sealed and left adjacent to the boring locations. Douglas Aircraft Company will be advised of the contents of the drums, their locations, and the need for proper management of the drill cuttings.

A.1.7 <u>Decontamination</u>

Augers and drilling equipment will be steam-cleaned between each boring and/or well to minimize the possibility of cross-contamination. The modified California sampler and brass tubes will be cleaned as follows

- o Potable water wash to remove mud and soil;
- o Potable water with Liquinox detergent;
- o Potable water rinse to remove detergent;
- o Deionized water rinse; and
- o Paper towel dry off.

A.2 <u>SOIL SAMPLING</u>

Subsurface soil samples from soil borings will be collected at the surface and at approximate 5-foot intervals below ground surface. Soil samples will be collected for organic vapor analyzer (OVA) headspace measurements, and for laboratory analyses. Soil samples will be collected using a modified California sampler, which holds four brass tubes and is 18 inches in length. The sampler will be driven to the sampling depth by dropping a 140-pound hammer approximately 30 inches. The number of blows (blow count) required to advance the sampler 1 foot will be recorded on the boring logs.

A.2.1 OVA Headspace Measurements

Field OVA headspace measurements will be taken from one of the soil samples collected at each sampling depth. This procedure is conducted by extruding the contents of one of the four brass tubes into a 1-pint glass jar. The jar's lid has a 1/4-inch diameter hole, which is sealed with duct tape. Organic vapors from the soil are allowed about 10 minutes to reach equilibrium inside the jar before an OVA probe is inserted through the hole into the jar and the vapor concentration is measured (in ppm).

A.2.2 Soil Sample Preparation

One or two tubes from the soil sampler will be prepared for laboratory analysis. The ends of the tubes will be covered with aluminum foil and plastic end caps and then sealed with electrical tape. Soil samples will be labeled with the following information:

- Project number
- Project name
- Boring number
- Sample number
- Sampling depth
- Sampling date
- Name of person collecting sample.

The soil samples will then be sealed in Ziploc plastic bags and placed on ice in a cooler. All soil samples will be delivered to a state-certified analytical laboratory for analysis. Chain-of-custody procedures, including the use of sample identification labels and chain-of-custody forms, will be used for tracking the collection and shipment of soils samples.

A.3 FIELD OBSERVATIONS

Observations will be made and recorded on boring logs by Woodward-Clyde Consultants (WCC) personnel during the drilling and sampling operations. These observations will relate to visual soil classifications, geologic and stratigraphic comments, observation well construction details, sampling efforts, OVA measurements, and other pertinent information.

A.4 FILTER PACK ANALYSIS

Selection of the proper filter pack material and well screen slot size is essential in collecting a sediment-free or low-sediment content water sample. In both the deep and shallow observation wells, the finest grained soil samples will be selected from below the water table for sieve analysis. Filter pack design calculations will be based on the grain size distribution obtained from these soil samples.

Soil sieve analyses will be conducted in the field by collecting a soil sample from below the water table with a modified California sampler. The soil sieve analysis consists of the following sequence:

- o The soil sample is heated with a portable propane stove to evaporate all water from the soil.
- o The dried sample is then weighed on a scale to the nearest gram.
- o The soil sample is then poured into the top of eight sieves and shaken for approximately 5 minutes.
- o The cumulative percent of the soil sample retained in each sieve is weighed and the weight plotted on a sand analysis curve, which graphically characterizes the grain size distribution of the soil.

Calculation of the filter pack size is performed by multiplying the 50-percent retained size of the formation sample by a factor of 2 (Johnson, 1986). This value is then plotted on the sand analysis curve. Through this point on the filter pack curve, a smooth curve is drawn representing material with a uniformity coefficient of 2 to 3, a value calculated by dividing the 40-percent retained value by the 90-percent value as shown in the equation below.

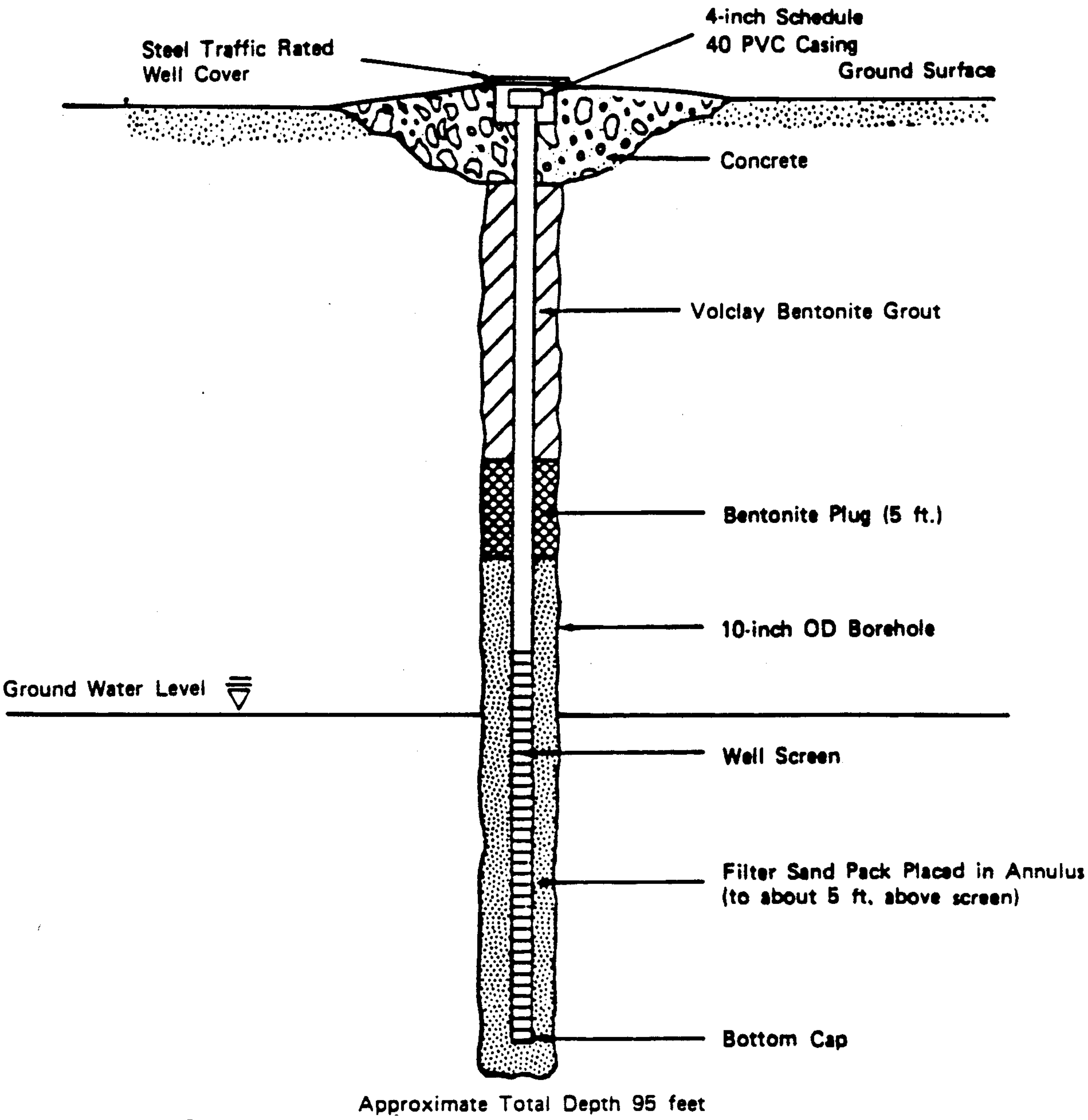
$$\text{Uniformity Coefficient (U.C.)} = \frac{\text{U.C.40}}{\text{U.C.90}}$$

This filter pack curve defines the ideal filter pack required to prevent the entry of fine silts, sands, and clays into the observation wells. A ready-made filter pack material is then selected that best matches the calculated filter pack curve; custom-made filter pack materials are not readily available. A screen slot size will be chosen that will retain 95 percent of the selected filter pack; an example of this procedure is shown in Figure A-3.

A.5 WELL DEVELOPMENT AND WATER SAMPLING

All observation wells will be developed by a sand bailer and surge block method and then pumped with a submersible pump. Each well will have a minimum of three borehole volumes of ground water removed; pH, electrical conductivity (EC), and temperature will then be allowed to stabilize. Development will continue until total settleable solids do not exceed 10 ppm. Also, any water introduced into the well during well construction will be removed, in addition to the volumes of water stated above.

Each observation well will have a minimum of three well casing volumes removed before a ground water sample is collected. EC, pH, and temperature will be recorded from each 5 to 10 gallons of ground water removed from the well. Stabilized EC, pH, and temperature values will indicate that ground water from the aquifer formation is being extracted from the well. All water samples shall have less than 10 ppm of settleable solids. The water removed from the wells will be stored on-site prior to disposal.



NOT TO SCALE

Project: DOUGLAS AIRCRAFT COMPANY **Project No.** 8841863G	BASIC SHALLOW OBSERVATION WELL DETAILS	Fig. A-1

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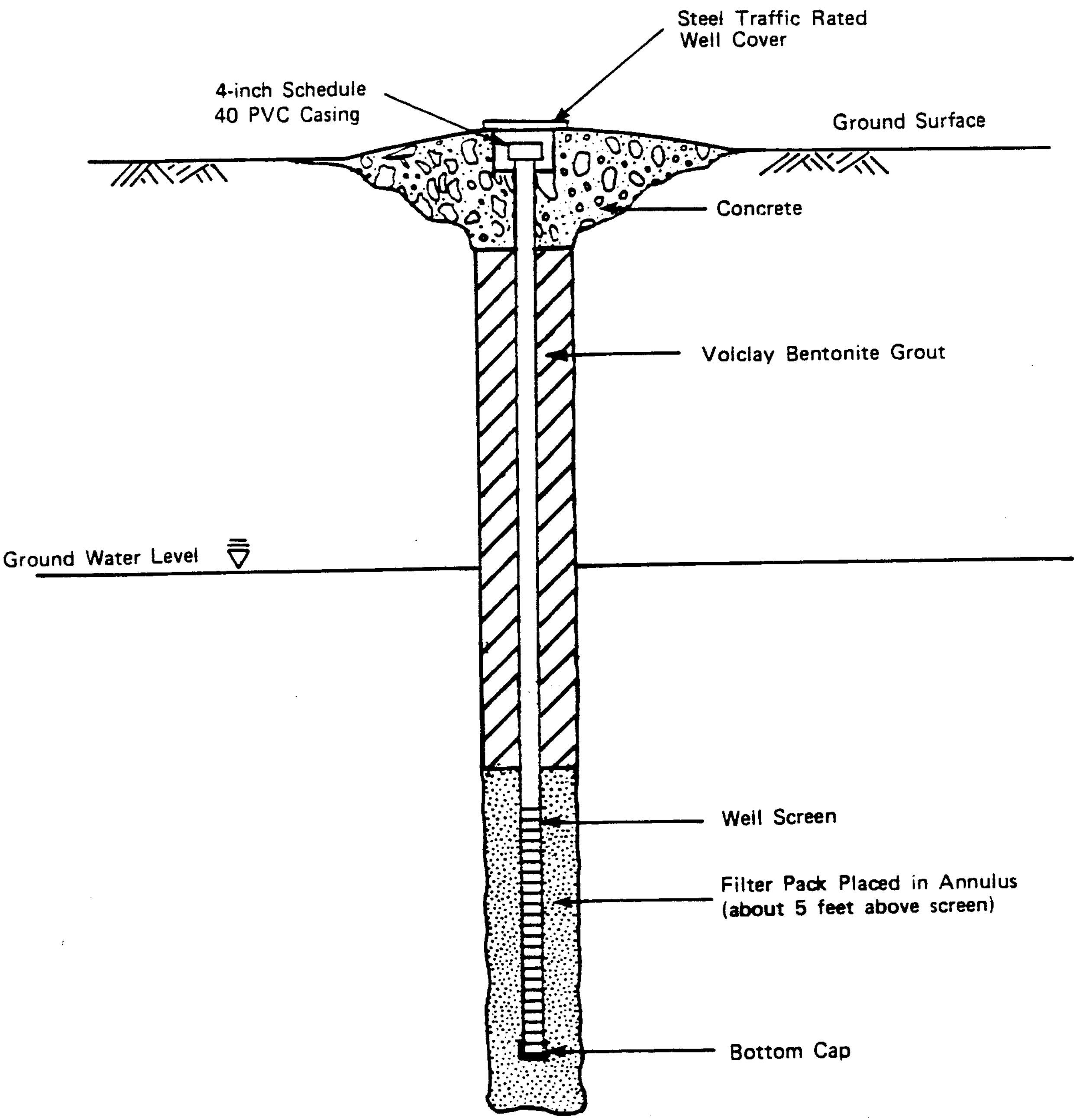


NOT TO SCALE

Approximate Total Depth 140 feet

Project: DOUGLAS AIRCRAFT COMPANY **Project No.** 8841863G	BASIC DEEP OBSERVATION WELL DETAILS	Fig. A-2

WOODWARD–CLYDE CONSULTANTS

BOE-C6-0220681

Well Name: Lone Star # 0/30 Sand

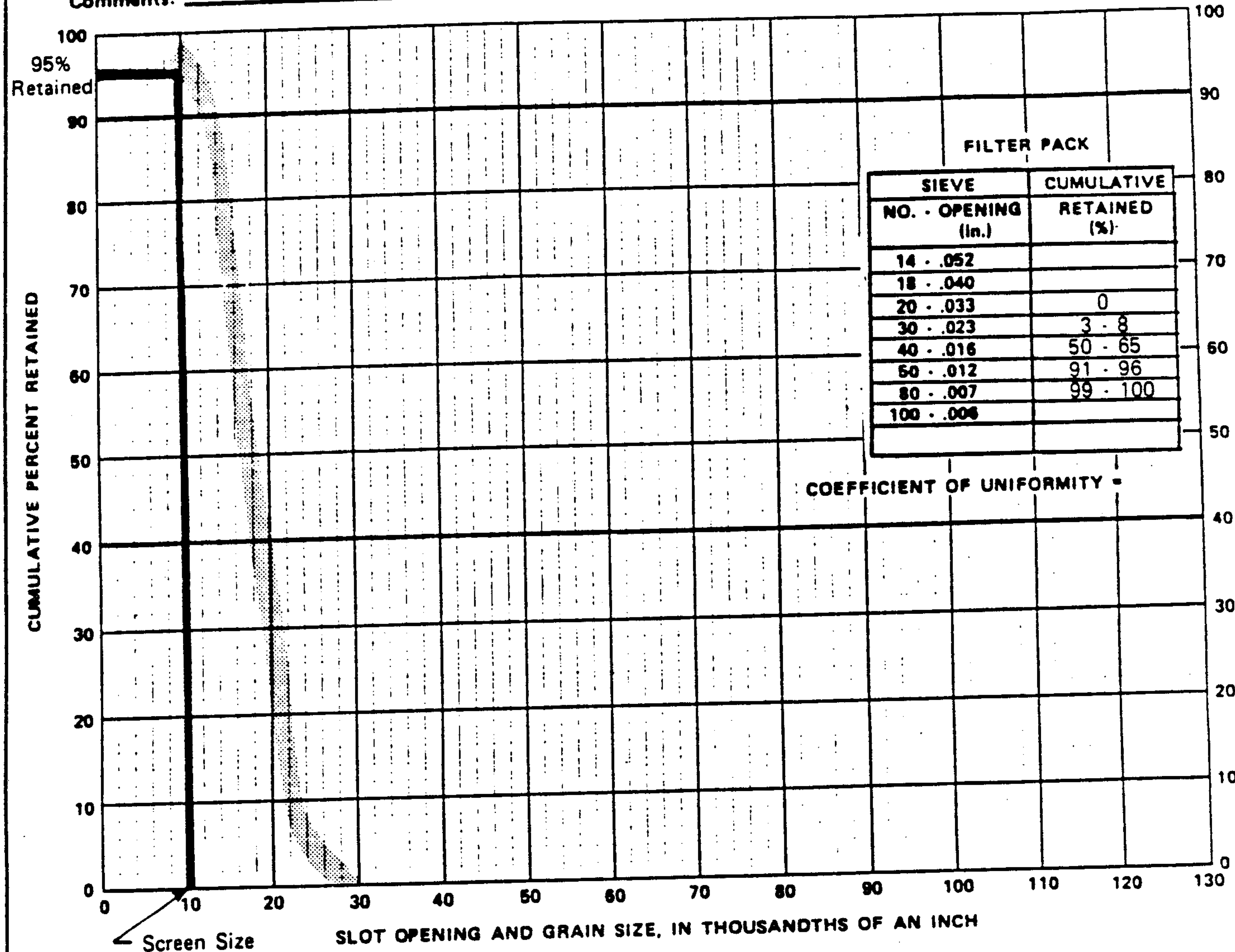
Date: 3 August 1988

Well Location: ______

Sample Depth: ______

Performed By: B. Jacobs

Comments:



FILTER PACK

SIEVE NO. - OPENING (in.)	CUMULATIVE RETAINED (%)
14 - .052	
18 - .040	
20 - .033	0
30 - .023	3 - 8
40 - .016	50 - 65
50 - .012	91 - 96
80 - .007	99 - 100
100 - .006	

COEFFICIENT OF UNIFORMITY =

SIEVE NO. - OPENING (in.)	SAMPLE WEIGHT (gms)	CUMULATIVE PERCENT RETAINED (%)	PASSING (%)
14 - .052			
18 - .040			
20 - .033			
30 - .023			
40 - .016			
50 - .012			
80 - .007			
100 - .006			
Bottom Pan			

Notes:

Uniformity Coefficient = $\frac{.020}{.013}$ = 1.54

Recommended Slot Opening: .010 inch - 10 Slot

Project DOUGLAS AIRCRAFT Project No. 8841863G	SAND ANALYSIS - ***LONE STAR*** # 0/30 SAND	Fig. A-3

BOE-C6-0220682